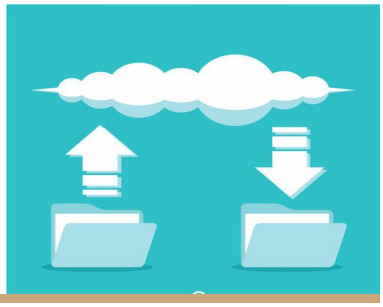
Hackerearth

EXL™ Hackathon

Cloud Agnostic File Storage System

BY : Gana Sai Praveen. K (Team: Gana_Rko)



Problem Statement:

The current solution processes backend requests and generates reports in .pdf, .csv, or .pdm file formats. These reports are then uploaded on an on-premises shared file server. Since the solution is now hosted on cloud, a file-server-based model is not the optimum solution for file storage.

Though transitioning file storage from on-premises to cloud can be achieved easily, clients have their choices of cloud provider, which requires customization for every transition. A cloud-agnostic storage solution can address this problem.

Can you build a solution that is agnostic of the cloud provider for storing and retrieving files, i.e. one solution that supports storage and retrieval of files from AWS S3 bucket, Azure Blob storage, or Google Cloud storage.

Key takeaways from Problem Statement

- The Problem **isn't about having storage system in cloud** (highlighted in red)
- The soul of the problem is about **providing clients the flexibility on how we store** their generated reports. (highlighted in green)
- Observing the Storage Options ( ), The solution would be better, if we can take advantage of the features these Cloud providers offer on Global scale.
- Key aspects considered during the design: (from exl management side)
    - **Accessibility, Scalability, Cost, Security and Time**
- So this solution will focus majorly in:
    - **Flexibility** to Clients for storing their reports
    - **Accessibility** of the reports for the Clients
    - **Affordability** of the reports for the Clients
    - **Security** of The Stored Data (symmetric, asymmetric and default)

Expected Solution (from webpage)

Task

- Minimum
    - Working API-based implementation
        - It should be capable of storing and retrieving files in any cloud provider.
        - It should adhere to the best standard security guidelines.
        - It should support AWS and Azure at least.
    - Intermediate
        - AWS instance
    - Advanced
        - Cloud-provider support can be enhanced to GCP and other cloud providers as well

Evaluation Criteria:

1. Concept and solution design has major weightage in evaluation criteria
2. Candidate must complete all 3 mentioned uses cases i.e. upload, download and download with temporary access
3. At least 2 cloud providers must be utilized in the solution. Preferably AWS and Azure should be used in the provided solution
4. In the provided solution, appropriate handling of sensitive keys and information is expected. So any submission having proper handling of sensitive information will get more weightage
5. Any submitted code having compile-time error will not be accepted

Developer Guide:

1. Write a RESTful API that can be consumed by any application. This API should have appropriate operations to upload and download the files from cloud storage.
2. API should support the programmatic access to desired cloud services.
3. API should follow standard security guidelines while connecting to cloud services
4. For uploading the files, API should allow only authorized users
5. Authorized users can obviously always download the files.
6. The application can allow some guest users who need only temporary access to some stored files. API should be capable of providing temporary access for a limited time interval also to access a particular file. For example a guest user is providing a dedicated file name. The API should return a temporary URL from which the user can access the required file for a limited time interval.

Solution

- The Solution consists of three micro services one is called a Template Server, the Report Server and User Manager (written in Django)
- Here's the description of each of them

User Management Server

- This is a microservice backed up with a mongoDB (locally in docker for prototype)
- This service will be only made available to EXL admins who can create users/guests for accessing reports on the report server.
- EXl admins can create a user object in mongoDB like this for a specific client and restrict access to reports as these objects will be considered by template server and report servers while processing users requests.
- Here's a sample user object we'll be using in the demo

User Object

```
{
    _id: ObjectId('62cf1b08fa97d74097e030f1'),
    user_id: 'gsp-infra-hr-user',
    user_name: 'hr-user',
    templates: [
        'gsp-infra-employees-reports'
    ],
    token: BinData(3, 'j3eYfTeTT1uJTER/IBbd+Q=='),
    guest_mode: 'disabled',
    updated_on: '13/07/2022 19:20:40',
    end_time: 'NA'
}
```

← Back

Guest object

```
{
    _id: ObjectId('62cf1b5efa97d74097e030f2'),
    user_id: 'gsp-infra-hr-guest',
    user_name: 'hr-guest',
    templates: [
        'gsp-infra-employees-reports'
    ],
    token: BinData(3, 'q7P6ttuDT2G9lJyJNL+IHw=='),
    guest_mode: 'enabled',
    updated_on: '13/07/2022 19:25:59',
    end_time: '15/07/2022 00:00:00'
}
```

← Back

- Fields in the Object:
    - **_id:** id generated by mongoDB per Object
    - **user_id:** uniques id assigned by our template server for one template
    - **templates:** Templates that a user can have access to, each template will in turn have multiple reports/report patterns.(easy for giving access to users, guests in bulk)
    - **token:**
        - Token will be generated per each object in users collection and this token must be provided by users/guests when calling apis of template/report servers.
        - Template Server and report server will use **users collection objects** and compare user_id and token of respective object with the username and password it receives along with api requests and authenticate requests accordingly.
    - **guest_mode:**
        - Isolate guests from client users and restrict guests to access limited apis. Here in prototype guests only get temporary links to download report, all other apis will be in accessible
        - To convert guests to users easily without creating new user objects.
    - **updated_on:**
        - Date-Time on which a user/guest object is updated
    - **end_time:**
        - This only applies to users of type guest
        - When Creating a guest user EXl admin has to specify a time limit in the number of days this guest would be able to use the apis of the report server.
        - This field will be taken into account by the report server while fetching reports across cloud buckets, thus giving temporary access to guest users, where time limits can be imposed dynamically by EXL admins based on client requirement and policy towards guest access to their reports.

Template Server

- This microservice is also backed up with the same mongoDB
- This will enable our Clients to define a template with various properties on how a report can be stored, they define,modify templates here and specify on what sort of their reports this template should be considered while storing the report on cloud providers.
- Here's a sample template from the prototype. This mongoDB object represents what fields a client can specify in a template and they will be used while storing files of clients choice.

```
{
    _id: ObjectId('62bf2a3763580658a8a5de2c'),
    template_id: 'gsp-infra-employees-reports',
    template_name: 'employees-reports',
    company_name: 'gsp-infra',
    encrypt_key: 'NA',
    compression_algo: 'hoffman-abc',
    storage_points: [
        'aws-usw1-archive',
        'gcp-euw1-standard'
    ],
    optimal_store_point: 'Decide by internal Processing',
    file_name_patterns: [
        'employee-health-survey-report.pdf',
        'employee-salary-spending-report.pdf',
        'employee-feedback-report.pdf'
    ]
}
```

Back

- Fields in the Object:
    - **_id:** id generated by mongoDb per Object
    - **template_id:** uniques id assigned by our template server for one template
    - **company_name:** Name of the client/Company owning this report
    - **encrypt_key:**
        - Security is a serious concern, while storing reports. As some reports might contain proprietary findings/stats/data too. All major Cloud providers provide encryption (managed by them, with our encrypt key no encryption at all etc..).
        - Here in this field clients can provide their own encryption key to encrypt/decrypt his report data. This allows him to use both symmetric and asymmetric encryptions for the generated report, depending on their need of confidentiality.
        - For symmetric encryption they can just provide the key and in case of asymmetric encryption they can provide a public key in which case no-one but only they can decrypt the report after it got encrypted and stored.
    - **compression_algo:**
        - As clients will be billed in one way or the other for their reports storage, that we manage. It's important to optimize the cost of storage for them too.
        - One way to save bucks is, via compressing files, while storing them, but usually some cloud-providers provide this feature and some don't.
        - But what if we have an algorithm which compresses files we generate to much smaller size?. The problem with cloud provides is that due to their large infrastructure and global presence, they cannot implement use-case specific procedures effectively, at least not at the same pace as the development of new features in the real world.
        - Thus this particular field will help us to implement use case specific compression to make storage options more affordable to our clients.

- **storage_points:**
  - Each entry here will follow the format
    Cloud-Provider - Storage Bucket Location - Type of Storage

    Example: ***gcp-euw1-standard***

  - **Cloud-Provider:** Cloud Provider they choose to go with, this part enables them to store reports across multiple cloud providers, Cloud Agnostic isn't it !!?? :-)
  - **Bucket Location:** As we now enable clients to choose from multiple storage providers, it'll be more useful if we also allow them to choose where to store their reports (this matters for accessibility).
  - **Type of Storage:** Almost all cloud providers have different types of storage (SSD, HDD etc) with different options, as clients will be aware of the way they use these reports they can use this aspect to optimize their spending.(this matters for affordability).
  - **Lifespan:** Some reports might not be needed forever, so this can set a max stay period for a report in a cloud bucket. After this period of time this report object can be moved to cheaper storage or removed based on clients requirements. (not implemented in proto type)
- **file_name_patterns:**
  - It'll be a huge burden for our client, if he was asked options to customize storage options for every report we generate
  - So to bypass this trouble, we included this field, where clients can simply define their report_names or patterns in the template once for all.
  - Report Server while uploading the report will check for the template with matching report name and apply all customizations from the above described options while storing that file.
- **optimal_store_point:**
  - This field will help report servers to ease out on computation while storing reports over multiple storage providers. (not operational in prototype)

Report Server

- This is microservice backed up with the same mongoDB as Template Server
- This server will be coupled with our report Generator Service to store files in the cloud.
- This micro service creates a metadata object in mongoDB for each report it stores.
- Here's a sample template from prototype

```
{
    _id: ObjectId('62c1783fb9bcd23d4ec7a724'),
    report_id: 'gsp-infra-temp-reports/employee-health-survey-report.pdf',
    name: 'temp-reports/employee-health-survey-report.pdf',
    template_id: 'gsp-infra-employees-reports',
    company_name: 'gsp-infra',
    storage_object_ids: [
        'aws-usw1-archive-exl_gsp-infra_temp-reports/employee-health-survey-report.pdf',
        'gcp-euw1-standard-exl_gsp-infra_temp-reports/employee-health-survey-report.pdf'
    ],
    storage_points: [
        'aws-usw1-archive',
        'gcp-euw1-standard'
    ],
    optimal_store_point: 'Decide by internal Processing'
}
```

- Fields in the Report metadata Object:
    - **_id:** id generated by mongoDb per Object
    - **report_id:** uniques id assigned by our report server for each report
    - **name:** Name of the report
    - **template_id:**
        - ID of Template used while storing this report, as we'll require some properties in that template while viewing this report.
        - In case of encryption or custom compression Algo etc..
    - **company_name:** Name of the client/Company owning this report
    - **storage_object_ids:** Object id in the buckets where they were stored, we require this for retrieval/ download of the reports for our clients.
    - **storage_points:**
        - Each entry here will follow the format

          Cloud-Provider - Storage Bucket Location - Type of Storage

          Example: ***gcp-euw1-standard***

        - Property represents pretty much the same details, but our client wants to delete one report specifically in one region. Then we can use this property and while fetching data we can use these details and set optimal_store_point from where we can retrieve reports fast and with less egress costs on our side.
    - **optimal_store_point:**
        - This is the Field we assign for each report based on user activity, how many times the report is being fetched and in which regions across the globe.
        - Simply, we assign this for each report based on client usage patterns over time, making the report fetching from cloud servers faster and cheaper.

Demo of Prototype Submission

- **Setting the Infra:**
  - ☐ In the folder docker setups just run **docker compose up -d** command once in mongo-db folder and minio folder.
  - ☐ Mongo-db will provide necessary databases needed for our two services i.e Template Server and report server to work.
  - ☐ Minio is a container that emulates the storage system similar to object storage, for the demo purpose of the prototype and to implement the above discussed customizations locally we used this container system to emulate OCI and Azure. When you run **docker compose up -d** in this folder, you'll find two containers getting started.
  - ☐ When all the four containers are up (assuming no conflicts while pulling images or ports being blocked), you should see this output for **docker ps** command. (added formatting for neat image)

```
ganarko@gana-mnet:~/.../dockersetups-prod/minio$ docker ps --format "{{.Names}}: \t{{.Status}}: \t{{.Ports}}"
minio-azure:    Up About a minute:      0.0.0.0:9020->9000/tcp, :::9020->9000/tcp, 0.0.0.0:9021->9001/tcp, :::9021->9001/tcp
minio-oci:      Up About a minute:      0.0.0.0:9010->9000/tcp, :::9010->9000/tcp, 0.0.0.0:9011->9001/tcp, :::9011->9001/tcp
```

  - ☐ Please note minio containers here emulate behavior of object storage of S3 and GCS, this gives me flexibility to showcase my solution without creating accounts across multiple cloud platforms.
  - ☐ Now you can run both the micro services by going into the **file_server** directory and running the command **python3 manage.py runserver.py**
  - ☐ Now you can import and use the postman collection to test the process.
  - ☐ Create template → Generate Report (for now we just create a pdf file with give text content) → Save it to minio storage buckets (based on template properties for the associated report name)

What our Solution Achieves for Client:

- **Client-Flexibility:**
  - ☐ Clients can Group multiple reports in one template and define storage properties once and for all. (very handy for clients with huge number of reports)
  - ☐ Client can customize type of storage bucket (Optimizes cost)
  - ☐ Client can choose storage location (faster access on Global Scale, can help a lot with latency if reports were accessed Globally)
  - ☐ Client can choose different cloud storage providers across multiple regions (For More reliability and cost efficiency)
  - ☐ Compression feature will further enable client to reduce storage size and costs (Highly useful for less frequently used reports)
- **Security:** The Solution was designed in such a way that client can have maximum possible options in terms of security
  - ☐ **No Encryption**
  - ☐ **Default Cloud provider based Standard Encryption** (GCS - yes, AWS - No)
  - ☐ **Cloud Provider Encryption based on EXL Keys** (GCS - yes, AWS - yes)
  - ☐ **Symmetric Encryption from Report Server Service**
    - client will store his key in our mongoDB template object, in case he doesn't want to trust cloud Providers EXL associate with.
  - ☐ **Asymmetric Encryption**
    - Client can provide a public key in template, keeping his private key with him, this way except the client no one can decrypt the generated report except him, though client will get encrypted object served thus need to decrypt in manually later.
- **Cost:** Customization using templates model offers clients to reduce costs in various aspects:
  - ☐ By choosing cheaper storage for unimportant reports,
  - ☐ Storing files in cheaper locations globally across multiple Storage providers
  - ☐ Storing less frequently used files in compressed form to reduce storage size and cost

What our Solution Achieves for EXL:

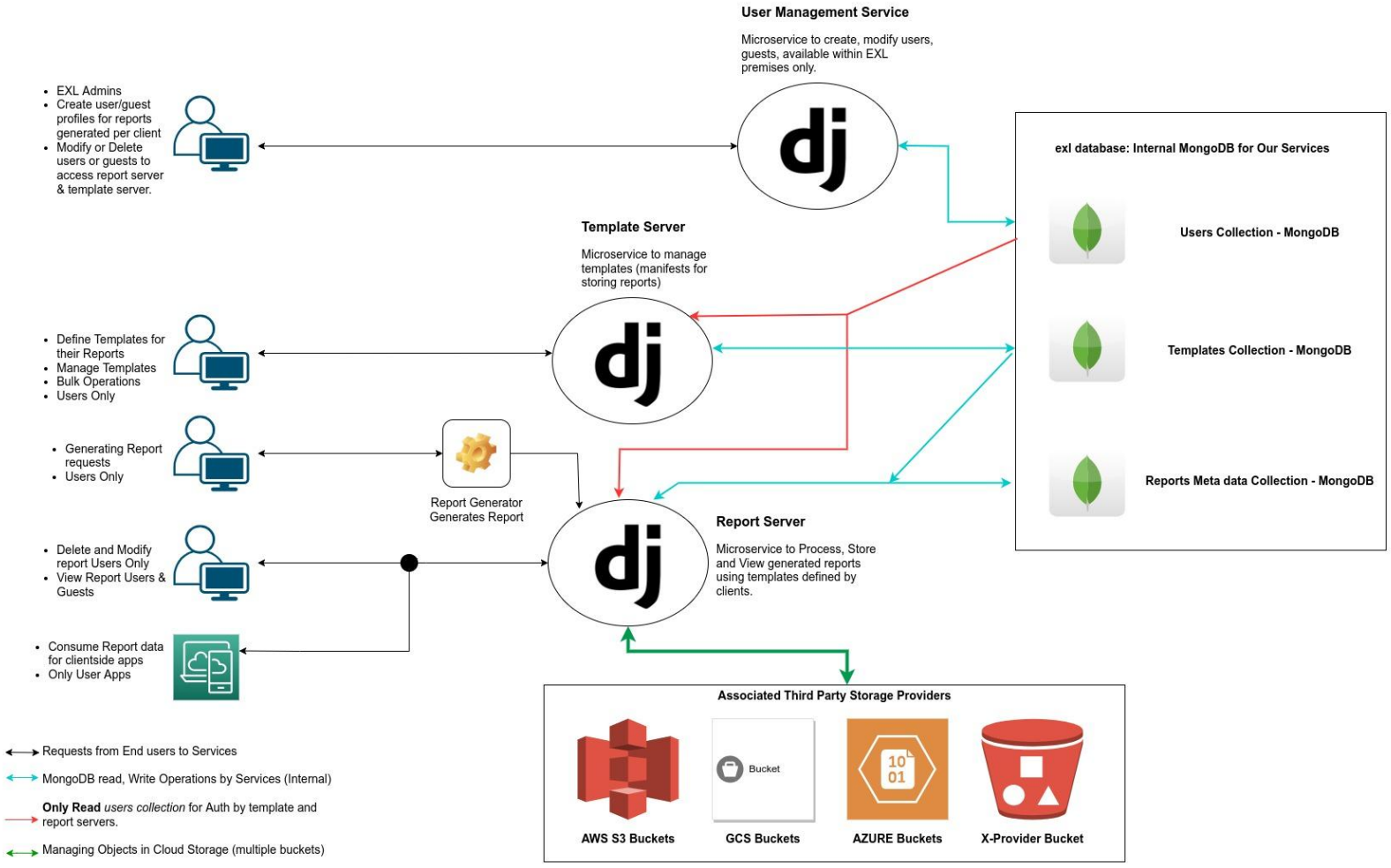
- **Reliability**
  - ☐ In the Solution each service can be containerized thus can be deployed as kubernetes clusters giving us maximum chance to have high availability.
- **Scalability**
  - ☐ Solution can be scalable based on our requirement as three micro services are independent of each other. We can scale any individual component, based on our requirements.
- **Client Satisfaction**
  - ☐ As our solution design allows clients to customize various aspects, clients would be happy to have options.
- **Cost of Operations**
  - ☐ Optimal Storage point while uploading a report will reduce computation resource usage burden, especially when storing reports in multiple location buckets.
  - ☐ Optimal Storage point whale downloading report will help us to reduce latency while fetching a report from cloud storage.

Problems to be Addressed:

- **Authentication:** Prefer HTTPS for in end product
- **Tightly Coupled Services:** In this case we are just generating a simple pdf report on api call for demo, but practically that report generating service will be a whole other app doing the work, so how to effectively send generated reports to the report server?
    - ☐ **Possible Solutions:** Mount storage across two pods or run as sidecar or transfer report from report generator service to report server using (SFTP).
- **Reliability:** What happens when a report fails to upload Or incase of partial upload
    - ☐ **Possible Solution:** Scheduled retries with acknowledgement
- **Collision:** In-case same file-name/pattern appeared in more than one template?
    - ☐ **Possible Solution:** Assign Priority Score for templates, so when collision happens templates with higher Score will be taken into consideration.
- **Template Change:** In-case of template modification, what will happen to already stored reports, which used previous data of the template?.
    - ☐ **Possible Solution:** implementing versioning for Templates

Note:

- Reason to use object storage containers like minio is that it can perfectly replicate the process of storing objects within localhost and we get to visualize customization about multiple regions and buckets easily in this model, compared to doing the same by creating multiple accounts/buckets in multiple cloud consoles.
- In-case of django/docker-compose/python version incompatibility or any other blocker, you can always see the demo-video for how the prototype operates**.**
- To further understand the architecture of the solution you can see the high level Architecture Diagram for the solution. **(*exl-design-phaseB-diagram.jpg*)**



Resources:

- References for encryption:
  - How to Encrypt and Decrypt Files in Python - Python Code
  - Symmetric vs. Asymmetric Encryption - What are differences?
  - GCS Encryption
  - AWS S3 encryption
- References for compression:
  - All The Ways to Compress and Archive Files in Python | by Martin Heinz | Towards Data Science
  - python - How to compress a large file? - Stack Overflow
  - How to Compress files with ZIPFILE module in Python.
  - GCS Compression
  - AWS | S3 compression
- Docker setup: noSQL database and minio-storage set up:
  - MinIO | Guide